

SECTION 523 – COMPOSITE PILES

523.01 Description.

This work shall consist of designing, furnishing and installation of fiberglass-concrete composite piles that may be used for the construction of fender systems and dolphins. The work will include all equipment, materials, labor, and all else necessary to install the piles as shown on the plans.

MATERIALS

523.02 Materials.

Hollow reinforcing composite tubes shall be produced of composite FRP (Fiber Reinforced Polymer) materials that have been formed by means of pultrusion, filament winding, scrim, or by other methods of production. E-Glass or other continuous fiber reinforcement shall be incorporated in the shell and shall be impregnated with vinyl ester, polyester, or epoxy resin. The content of the structural wall shall be 50 to 70 percent glass with a minimum of 25 percent resin (by weight). The manufactured tubes shall be capable of withstanding normal handling, shipment, and installation procedures.

FRP/Polymer Reinforcing Tubes shall exhibit superior corrosion and ultraviolet resistance as demonstrated when exposed to an accelerated environmental test chamber for not less than 3,600 hours. The tube shall show no structural failure (i.e. <10% loss of strength) as a result of exposure to moisture and lamps required in ASTM G-23, G-26, G-53 and B-117, or equivalent tests as approved by the Engineer.

The fiberglass tubes to be used in the fabrication of composite piles shall provide sufficient cross section and strength to withstand stresses incurred by fabrication, handling and driving of the piles to the required resistance.

1. Tolerances. Acceptable tolerances for the fiberglass tubes shall be as follows:

Minimum Length (inches)	-	estimated/ordered length \pm 1 inch
Maximum Sweep (inches)*	-	0.08% of total length
Ends out of Square (inches)	-	1.0% of diameter

* Sweep – deviation from straightness, measured at several points about the pile circumference while the pile is not subjected to bending stresses.

2. Physical Properties. As defined in ASTM D 2310 or D 2996, fiberglass products designated as follows shall be used:

Class: RTRP (Reinforced Thermosetting Resin Pipe)
Type: Type I (filament wound)
Grade: Grade 1 (Glass fiber reinforced epoxy resin pipe),
Grade 2 (Glass fiber reinforced polyester resin pipe) or
Vinylester resin, although there is no current ASTM Grade designation for
vinylester resin.

In the manufacture of fiberglass tubes resins containing ultraviolet (UV) inhibitors shall be used. A UV resistant film coating of a minimum 3 mils thickness to portions of piles remaining exposed after installation shall be applied.

Fiberglass tubes that have the minimum physical properties stated in the following table shall be used.

Nominal Tube Diameter (inch)		12	14	16
Elastic Moduli (ksi)	axial-tensile ¹	4000 ksi	3350 ksi	2800 ksi
	axial-compressive ²	2800 ksi	2350 ksi	1900 ksi
	hoop-tensile ³	4500 ksi	4500 ksi	4500 ksi
Strength (ksi)	axial-tensile	70 ksi	58 ksi	49 ksi
	axial-compressive	39 ksi	35 ksi	29 ksi
	hoop-tensile	35 ksi	35 ksi	35 ksi

¹ ASTM D 2105

² ASTM D 695 (modified – see Allowable Degradation)

³ ASTM D 1599

3. Allowable Degradation

The total UV resistance of the resin inhibitors and the color film shall be sufficient to limit loss of properties, as specified in the following table, after exposure to light and water spray or salt spray for a duration of 3600 hours. Certification of exposure testing that has been conducted in accordance with at least one of the following ASTM methods: G 23, G 26, G 53 or B 117 shall be provided to the Engineer.

Property	Allowable loss/change	Test Designation
Axial tensile strength loss	≤ 10%	ASTM D 2105
Axial compressive strength loss	≤ 10%	ASTM D 695 (modified)*
Hoop tensile strength loss	≤ 10%	ASTM D 1599
Color film adhesion loss	≤ 10%	ASTM D 4541
Color change	ΔE 25	ASTM E 308 and D 2244

* Modify ASTM D 695 as follows:

Test specimen dimensions:

diameter: full diameter of tube being tested

height: 1 inch

Do not use the compression tool described in ASTM D 695. Center the specimen in the compression test machine and place a steel plate on top of the specimen to evenly distribute the load from the test machine.

Dimensional and physical stability of materials used in the manufacture of composite piles will be evaluated for compatibility by ASTM D 696 (Standard Test Method for Coefficient of Linear Thermal Expansion of Plastics between –22° F and 86° F).

Color shall be permanent. Color to be provided shall be black or gray.

As a minimum, concrete infill for composite piles shall conform to Class A concrete strength requirements. In addition, a positive connection such as either using a composite tube with a textured inside surface, or use of a chemical bonding agent, or by using shrinkage compensating concrete shall be established between the composite tube and concrete core to ensure composite action.

The Contractor shall submit independent test lab results confirming that the composite piles meet or exceed the following ultimate flexural strength value:

1400 kip inches for a 12 inch nominal dimension composite pile.

Wrapping for the composite piles that are to be placed in clusters shall be stainless steel strips conforming to ASTM A480, Type 316, and that consist of, as a minimum, ½ inch wide material.

The following manufacturers are known to supply products that comply with these requirements:

Hardcore Composites
618 Lambsons Lane
New Castle, DE 19710
Phone: (302) 442-5900

Lancaster Composite
1000 Houston Street
P.O. Box 247
Columbia, PA 17512
Phone: (717) 872-8999

Plastic Pilings, Inc,
1485 South Willow Avenue
Rialto, CA 92376
Phone: (909) 874-4080

CONSTRUCTION

523.03 Construction Details.

- A. Working Drawings. Submit working drawings according to the requirements of Subsection 105.04. The submission shall include calculations to establish the flexural strength requirement stated above.
- B. Additional Submittals. Submit the following documentation and details to the Engineer for approval at least thirty (30) days prior to driving the piles.
 - 1. Documentation indicating the fiberglass tubing designations as per ASTM D 2310 or D 2996, diameter and wall thickness.
 - 2. Method of placing concrete in fiberglass tubes.
 - 3. Details for splices, shoes and pile top connections as necessary.

- C. Placing Concrete. Place the concrete in the fiberglass tubes in one continuous bottom to top operation in a manner that prevents voids from forming.
- D. Storage and Handling. Do not drive piles until 30 days after concrete has been placed in the tubes. Store and handle piles to avoid damage to all components including fiberglass tubes, protective coatings and concrete. During storage, place the piles on minimum 6 inch wide timber cribbing arranged to give even support and to maintain straightness within the tolerance specified above.
- E. Lifting Piles. Use only fabric slings. Do not use chain or cable in direct contact with the piles.
- F. Splices. Use full length piles where practicable. Where splices are unavoidable their number and locations will be subject to written approval by the Engineer. Splicing details shall be submitted to the Engineer for approval.
- G. Shoes. Provide steel shoes for composite piles, when required. Install shoes on piles in conformance with details submitted to and approved by the Engineer.
- H. Equipment for Driving Piles.
1. Equipment for driving composite shall conform to the requirements of Subsection 505.03.

A hammer with a minimum rated striking energy of 13,000 lbs.ft per blow shall be used for driving composite piles.

Hammers having greater striking energy may be used upon approval by the Engineer.
 2. As per the requirements of Subsection 505.03 G., Use an approved hammer cushion block to transfer pile hammer energy to the pile. Equip each hammer with a helmet/drive head to fit the diameter of the pile to be driven.
 3. As per the requirements of Subsection 505.03 G., Use an approved pile cushion block to prevent damage to the pile. At a minimum frequency, inspect the pile cushion block after each pile is driven and replaced regularly as needed.
- I. Allowable Variation in Pile Alignment. Install composite piles truly vertical or accurately battered as indicated on the Contract Plans. The top of any pile driven its full length into the ground shall not vary from the plan location by more than 2 inches.
- J. Defective Composite Piles. The provisions of Subsection 505.08, in addition to the following, shall apply for determining composite pile defective characteristics:

The following will be causes for rejection of a pile:

1. Incorrect pile location or batter.
2. Pile damage from any cause prior to driving.
3. Insufficient concrete strength, based on testing of cylinders.

4. Pile broken by reason of internal defects (even if placed in the leads), or improper driving.
- K. Cutting Off Piles. Cut off the tops of composite piles at the elevation indicated on the Contract Plans, or as established by the Engineer. Cut the piles to a true plane, in accordance with the detail shown on the Contract Plans. All cut off lengths become the property of the Contractor.

COMPENSATION

523.04 Method of Measurement.

The quantity of Composite Piles will be the total number of linear feet of pile that is placed in accordance with the plans.

523.05 Basis of Payment.

Payment will be made under:

<i>Pay Item</i>	<i>Pay Unit</i>
COMPOSITE PILE, ____ INCH DIAMETER	LINEAR FOOT

Wrapping is to be paid for under the item "Composite Pile, ____ Inch Diameter".

No additional payment will be made for redriving of piles that are forced up by any cause. Costs shall include all material, labor, equipment, and other necessary items required for completing the work including storage costs, disposal of unused piles, repair to damaged piles, and transportation costs. Parts of pile cut off will not be included for payment.

SECTION 524 – COMPOSITE LUMBER

524.01 Description.

This work shall consist of furnishing and installing reinforced composite lumber (CL) wales for fender systems and smaller dimensional fiberglass reinforced CL for fender system platforms as shown on the drawings and specified herein.

MATERIALS

524.02 Materials.

COMPOSITE LUMBER (CL) - The plastic for CL shall be a mixture of one or more of the following recycled post consumer or post industrial thermoplastics: high-density polyethylene, medium-density polyethylene, low-density polyethylene. The plastic shall be mixed with appropriate colorants, UV inhibitors and antioxidants so that the resulting product meets the material property requirements specified in Table 1. below. CL shall not absorb moisture, corrode, rot, warp, splinter or crack. The outer skin shall be smooth and black in color unless otherwise specified in the contract plans. It shall contain hindered amine light stabilizers to provide sufficient resistance to ultraviolet light degradation so as to meet the requirements in Table 1 below.

FRP/Polymer that may be used in the manufacture of CL shall exhibit superior corrosion and ultraviolet resistance as demonstrated when exposed to accelerated environmental test chamber for not less than 3,600 hours. The tube shall show no structural failure (i.e. < 10% loss of strength) as a result of exposure to moisture and lamps required in ASTM G-23, G-26, G-53 and B-117, or equivalent tests as approved by the Engineer.

CL shall be manufactured as one continuous piece and shall undergo a post production operation to ensure that residual stresses are relieved. No joints or splices are permitted. CL shall consist of a dense outer skin surrounding a less dense core. Interior voids shall not exceed ___ inch in diameter. CL shall be free of twist and curvature. Dimensions and tolerances shall be in accordance with Table 2 below.

CL shall be reinforced by four (4) ___ inch fiberglass reinforcing rods spaced inside the four corners of the timber. Reinforcing rods shall be continuous and offer a minimum flexural strength of ___ Ksi when tested in accordance with ASTM D4476 and a minimum compressive strength of ___ Ksi when tested in accordance with ASTM D695. CL shall meet the structural properties listed in Table 3.

TABLE I: PLASTIC MATERIAL PROPERTIES

Density (ASTM D792)	Skin	55-63-lbs/ft ³
Density (ASTM E12)	Core	34-48-lbs/ft ³
Water Absorption (ASTM D570)	Skin Core	24 hrs: <0.5% wt. increase 2 hrs: <1.0% wt. increase 24 hrs: <3.0% wt. increase
Brittleness (ASTM D746)	Skin	No break at -40°F
Impact Resistance (ASTM D746)	Skin	Greater than 4.5 lbs-ft/ft
Hardness (ASTM D2240)	Skin	44-75 (Shore D)
Abrasion (ASTM D4060) Cycles = 10,000 Wheel = CS17 Load – 2.2 lbs	Skin	Weight Loss: <1.1x10 ⁻³ lbs Wear Index: 2.5 to 3.0
Chemical Resistance (ASTM D543)	Skin/Core Sea Water Gasoline No. 2 Diesel	<1.5% weight increase <7.5% weight increase <6.0% weight increase
Tensile Properties (ASTM D638)	Skin/Core	Minimum 500 Ksi at break
Compressive Modulus (ASTM D695)	Skin/Core	Minimum 40 Ksi
Coefficient of Friction (ASTM F489)	Skin	Maximum 0.25, wet or dry
Nail Pull-Out (ASTM D1761)	Skin/Core	Minimum 60 lbs

TABLE II: DIMENSIONS AND TOLERANCES

Plastic Timber	Dimension	Tolerance
Length	Per order	±6 in
Width	See Contract Plans	± 0.25 in
Height	See Contract Plans	± 0.25 in
Corner Radius		± 0.25 in
Outer Skin Thickness		± 0.126 in
Distance from outer surface to rebar elements		± 0.62 in
Straightness (gap, bend or bulge inside while lying on a flat surface)		<1.5 in per 10 ft length

TABLE III: STRUCTURAL PROPERTIES

Member Size	See Contract Plans
Modulus of Elasticity (as derived below)	Min. 405 Ksi
Stiffness, E.I.	Min. 1,087 Ksi
Yield Stress in Bending	Min. 4.5 Ksi
Weight	See Contract Plans

An independent laboratory report verifying the Modulus of Elasticity of a full size test specimen is to be included in the submittal package. The test is to be conducted as a three point bend test with a load applied in the center of a simply supported fourteen feet span, at a deflection rate of 0.25 inches per minute. The Modulus is to be taken at a strain of 0.01 inches per inch, where strain equals $(6) \times (\text{depth of cross section}) \times (\text{deflection}) / (\text{span length squared})$ and where Modulus of Elasticity equals $(\text{load}) \times (\text{span length cubed}) / [(48) \times (\text{deflection}) \times (\text{moment of inertia})]$.

524.03 Submittals.

The contractor shall submit copies of the CL manufacturer's standard and most recent product brochure for the product covered by this specification. According to the requirements of Subsection 106.04, the Contractor shall submit a written certification from the CL manufacturer that their product satisfies this specification and has been in service for a minimum of three (3) years on other bridge protection applications in the United States. This written certification shall include project owner information, project names, locations, contacts and phone numbers. Copies of material test reports and performance test data that support compliance with the specification requirements shall be submitted with the certification.

CONSTRUCTION

524.04 Construction Details.

Materials shall be protected at all times against exposure to extreme heat or impact. CL shall be shipped in a manner that will minimize scratching or damage to the outer surfaces. CL shall be stacked on dunnage above ground so that it may be easily inspected and stored in a manner that will avoid damage. CL shall be handled with nylon slings. Sharp instruments shall not be used in handling the product. CL damaged in shipping or handling will be rejected.

CL shall be cut, beveled, drilled, countersunk, and otherwise fabricated in accordance with the manufacturer's recommendations. Set all material accurately to required levels and lines, with members plumb and true and accurately cut and fitted. Securely attach all composite lumber to substrate by anchoring and fastening as shown on plans.

COMPENSATION

524.05 Method of Measurement

The quantity of CL will be measured in cubic feet computed on the basis of actual volumes and the shortest commercially available lengths which could be used.

524.06 Basis of Payment.

Payment will be made under:

<i>Pay Item</i>	<i>Pay Unit</i>
COMPOSITE LUMBER	CUBIC FOOT

Costs shall include all material, labor, equipment, fasteners, and other necessary items required for completing the work including storage costs, disposal of unused materials, and transportation costs.

No separate payment will be made for grout, plates, bolts, screws or other hardware for attaching the wales to the dolphins or for assembly/installation of the platform. The cost thereof is to be included in the pay item "Composite Lumber".